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DISSEMINATION STUDIES OF THE M25A2 RC GRENADE

by

Craig R. Allan

July 1972

DEPARTMENT OF THE ARMY
EDGEWOOD ARSENAL
Chemical Laboratory
Edgewood Arsenal, Maryland 21010

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Aerosol dissemination tests were conducted with standard and modified M25A2 grenades to identify and evaluate those parameters critical to obtaining increased powder dispersion efficiency. The effects of burster ratio, casing thickness, and powder size were considered.

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FOREWORD

The work described in this report was authorized under Project 1W062116A081, Chemical Dissemination and Dispersion Technology. This work was performed between April and November 1970. The experimental data are recorded in notebooks 8148 and 8421.

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DIGEST

Aerosol dissemination tests were conducted with standard and modified M25A2 grenades to identify and evaluate those parameters critical to obtaining increased powder dispersion efficiency. The effects of burster ratio, casing thickness, powder preparation, and agent subcarriers were considered.

It was found that:

1. A two- to threefold increase in dissemination efficiency can be realized by control of initial powder size.

2. The M25A2 burster can be reduced by one-half without adversely affecting dissemination efficiency.

3. Use of agent carriers may offer a technique for increasing effective cloud volume.

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DISSEMINATION STUDIES OF THE M25A2 RC GRENADE

I. INTRODUCTION.

Both bursting and pyrotechnic type grenades have value for riot control applications. The latter generates a large volume cloud over a period of many seconds, but the cloud is subject to thermal pluming, and the grenade can be returned by target personnel. A bursting grenade produces immediate agent effects for spot targets and cannot be returned, but does not create as large an instantaneous cloud as desired and could inflict injuries. This study of the M25A2, a bursting, powdered agent-filled grenade, was undertaken to investigate those parameters that influence its performance and determine how its dissemination efficiency and utility could be increased.

II. MATERIALS AND METHODS.

The M25A2 riot hand grenade is a 3-inch-diameter molded phenolic plastic sphere with a 0.1-inch wall thickness (0.25 inches in the center section). A central tube holds a C-12 detonator containing 0.73 grams of explosive. When filled with agent CS, the grenade has a nominal payload of 30 to 40 grams.

For these evaluation tests the grenade was filled with an innocuous test agent and functioned in a 157,000-liter blast chamber. The resulting aerosol cloud was mixed with stirring fans and sampled with vacuum filter probes over a 30-minute period following burst. From quantitative chemical analysis of the filters, cloud concentration decay was determined as a function of cloud life. The percent of initial grenade fill disseminated as $\leqslant$ 10-micron particles, which is approximated by the percent of fill airborne at 8 minutes, and the actual weight of powder aerosolized in this size range were used to compare performance for the variables studied. Resorcinol, which was used as the test agent, was prepared similarly to CS-2, i.e., ground and blended with hexamethyldisilazane- (HMDS) treated Cab-O-Sil. The initial particle size of the powders was determined with the Whitby centrifugal particle size analyzer. Chamber absolute humidity was maintained within a ±10% range for all trials.

III. EXPERIMENTAL RESULTS.

Replicate tests of the standard grenade filled with 14-micron-MMD resorcinol and positioned with its burster vertical were conducted under both air (5 feet) and ground burst conditions to establish baseline performance. The ground burst trials were less efficient at forming the aerosol, and signs of powder dumping, was noted (figure 1a). All subsequent testing was air burst.

Photographic coverage showed that the initial cloud formed a 6-foot-diameter by 4-foot-thick disk about the central burster axis. A number of large fragments entrained small amounts of agent 1 to 4 feet beyond the main cloud. Fragment velocity ranged from 140 to 250 ft/sec, averaging 210 ft/sec. The nominal fragment size distribution, based on collection of 93% of the casing was: 15% < 1/8 inch, 50% < 3/8 inch, and 100% < 1 inch. Average fragment weight was 0.6 gram.

The ratio of inert to burster weight, i.e., mass ratio, of these grenades is 225. To determine the sensitivity of dissemination efficiency to changes in mass ratio, an electrical detonator (NND211) and various amounts of tetryl were substituted for the standard C-12 detonator. A minor loss in efficiency (from 14% to 13%) resulted from more than doubling the mass ratio, whereas efficiency increased to 18% at approximately half the standard mass ratio; however, flashing of the aerosol cloud occurred for two trials at mass ratios below the standard (figure 1b).

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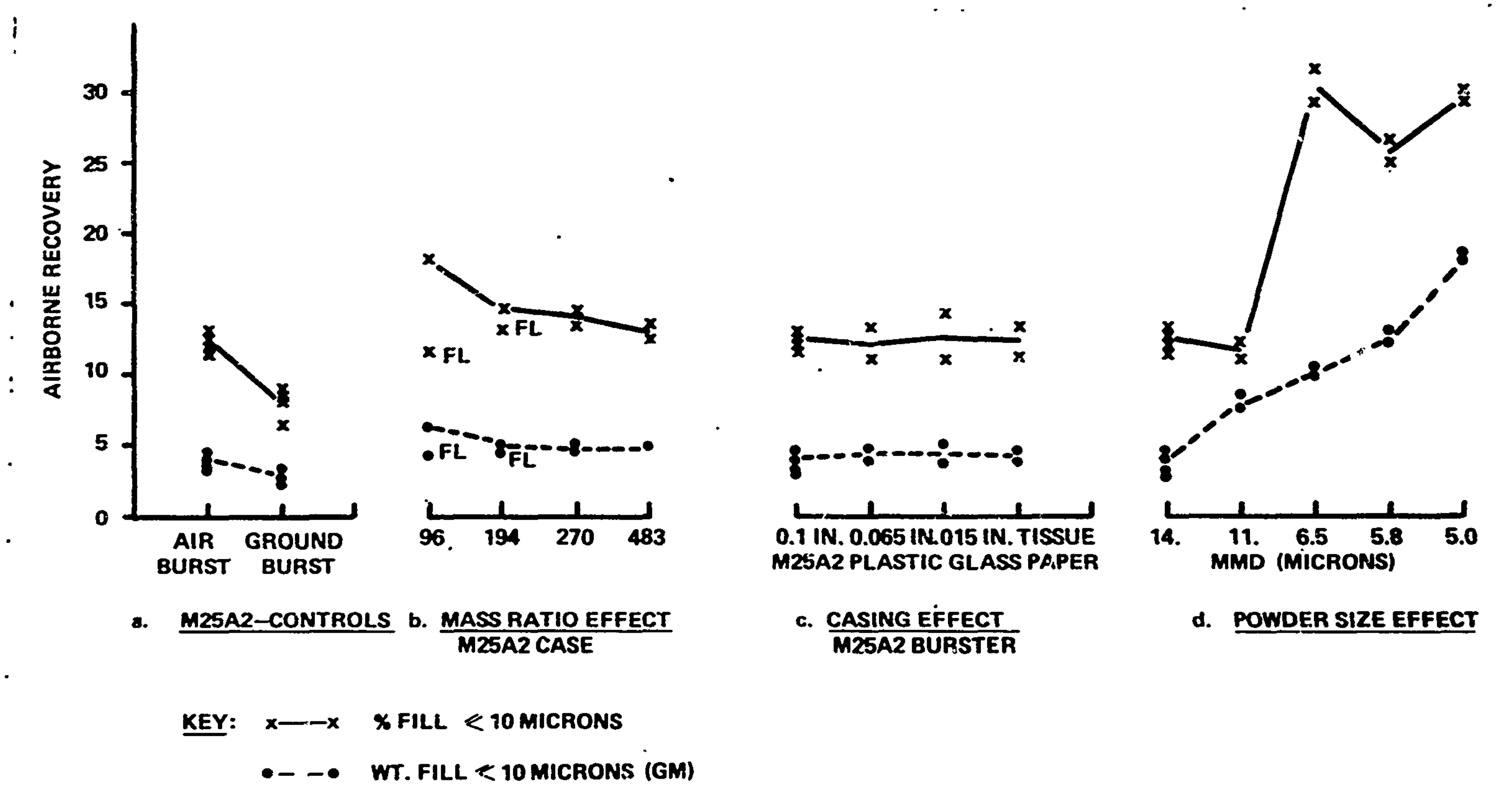

Figure 1. Dissemination Performance

To evaluate the effects of confinement caused by the relatively heavy M25A2 casing, grenades of the same size were fabricated of other materials, but retaining the standard C-12 detonator. Dissemination efficiency was unchanged for a 0.065-inch plastic case, a 0.015-inch glass case, and a tissue paper case (figure 1c).

The persistence of an aerosol cloud produced by this grenade is ultimately determined by the initial particle size of the agent, because the explosive force is insufficient to shatter these initial fill particles. Powder samples of different initial particle size were evaluated in the standard bomblet to determine this effect. In each case the resorcinol was blended with 5% HMDS-treated Cab-O-Sil. Compared to the powder used in the earlier trials (MMD = 14 microns), a sample of MMD = 11 microns produced no effective change in dissemination efficiency. However, three samples of MMD = 5.0 to 6.5 microns improved the grenade's performance by a factor of approximately two and one-half (figure 1d). The effect of a generally increasing loading density for these powders also contributed to a marked increase in weight of agent aerosolized.

Aerosol deposition samples from these trials showed large numbers of particle aggregates 20 to 50 microns in size, explaining why dissemination efficiencies were not as high as predicted for powders having these initial size distributions. To determine if these aggregates could be broken up during the dispersion process, an annular paper tube surrounding the burster was filled with ~ 200-micron NaCl. Dissemination efficiency did improve, but no material gain in terms of weight of agent airborne was achieved because of the loss in payload due to agent displaced by the inert salt layer (figure 2a).

In another attempt to reduce particle aggregation, 1% Vulcan (Cabot XC-722) millimicron highly conductive carbon was blended with the MMD = 6.5-micron powder sample as an antistatic additive. As the dissemination efficiency of this preparation was below that of the control, any antistatic benefit was overshadowed by the poorer dispersability of the particles when coated with the carbon (figure 2b). Using one other approach, large amounts (20% and 50%) of Santocel Z were blended into a base powder to evaluate whether aggregation could be reduced by separating the particles with an inert buffer material. Trial results showed this choice of material was not satisfactory. Dissemination efficiency at the 50% level was below that found when 20% Santocel Z was used, whereas active agent payload in both cases was sharply reduced because of the inert additive (figure 2c).

A series of trials was made with the MMD = 5.8-micron powder to determine if segmenting the M25A2 case into 16 pieces to reduce the rupture strength and provide large fragments would aid dispersion by entraining significant amounts of agent to a greater radius. These effects, however, were not achieved as the resulting data show no change in dissemination efficiency (figure 2d).

An additional modification was the inclusion of approximately 800 powder "carriers" in the grenade. These were plastic tubing, 3/16-inch-ID by 3/8-inch long, sealed at one end, and filled within the grenade during the powder vibration loading operation. The purpose of the carriers was to reduce powder compaction at detonation and to discharge fill during their dispersion over a greater distance than the powder alone would be dispersed. The carriers raised dissemination efficiency from the baseline of 26% to 31%; although only one trial was performed, a further increase to 34% was found when the carriers were used together with a segmented case (figure 2e). However, there was no corresponding gain in weight of agent aerosolized because of the reduced initial payload.

IV. DISCUSSION.

The baseline tests of the M25A2 produced an average airborne mass dissemination efficiency at 8 minutes (aerosol $\leq$ 10 microns) of 11.7% for air burst and 8.0% for ground burst.

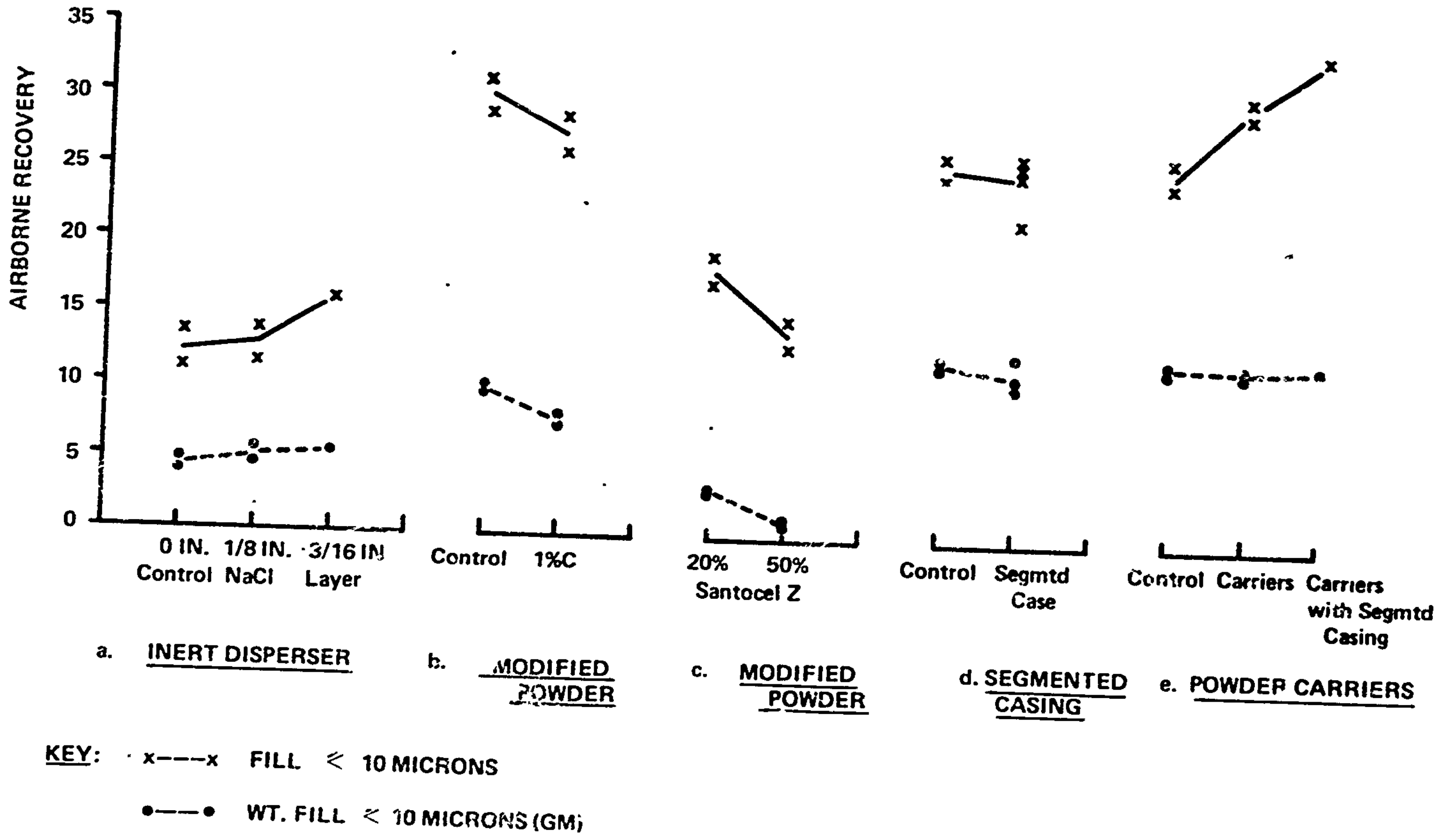

Figure 2. Dissemination Performance

This corresponds to 4.1 grams and 2.8 grams respectively of powder of this size actually aerosolized. The theoretical mass decay rate, based on the size distribution of the grenade fill, was plotted. This showed that 36% of the mass should still be airborne at 8 minutes. The actual powder dissemination efficiencies are 33% for air burst and 25% for ground burst of the above theoretical amounts. The material unaccounted for was lost by bulk dumping and the rapid fallout of large particle aggregates. These low dissemination efficiencies, the small initial cloud volume, and the presence of relatively large and high velocity fragments indicate the inability of this bomblet to effectively meet its design requirements, particularly under ground burst conditions.

Increasing burster weight is usually the most direct way to increase dissemination efficiency. However, the inert mass-to-burster ratio of this bomblet is initially so high that efficiency is insensitive to moderate changes in burster weight. An increase in efficiency of only 14% to 18% is seen when twice the amount of explosive is used. Use of more explosive increases the blast and fragment hazard and, in addition, at increased explosive levels cloud flashing occurred. However, this insensitivity to burster weight does mean that one-half the standard burster weight could be used and still produce equivalent performance while minimizing the blast and fragment hazards.

Casing thickness is an important parameter in other explosive dissemination systems, but, at least for these high mass ratio bomblets, changing case strength produced no effect on aerosolization. However, because the heavy M25A2 casing does not contribute to dissemination efficiency, it should be lightened to the limit of necessary structural strength to further minimize fragment hazard.

Of the variables studied, particle size of the fill is by far the most significant. For grenades containing $\simeq$ 5-micron MMD powder, 30% of the fill was aerosolized as $\leqslant$ 10 microns, compared to 12% for powders with MMD's of 11 and 14 microns. By reference, MMD $\leqslant$ 9 microns is specified for CS1 or CS2 payloads. These data emphasize the necessity for filling this type of munition with a very finely ground powder fill that has been treated to resist crystal growth and agglomeration while in the bulk state. The fill material also should be treated to produce a high bulk density product to maximize bomblet payload. For example, the 6.5-micron powder produced an efficiency of 30% or 10 grams $\leqslant$ 10 microns from a fill of 33 grams; the 5.0-micron powder of higher bulk density loaded to twice the payload (61 grams), also produced an efficiency of 30%, but disseminated 18 grams of powder $\leqslant$ 10 microns.

Materials added to aid dispersion, reduce static effects, or act as a buffer were not successful. It is hoped that a more systematic application of powder technology will be able to minimize the particle aggregation problem while meeting particle size requirements without resorting to any admixtures that would lower agent payload and could interfere with toxicological action.

With a CS fill of 37 grams and an initial cloud volume of 3.2 cu m, the M25A2 has the potential of an agent concentration of 11,000 mg/cu m. This is approximately 200 times the effective agent concentration to incapacitate 50% of target population with one breath. Although little work was done with the powder carrier concept, it may offer a technique to reduce this over-concentration of agent in the initial cloud and also quickly establish a greater effective cloud diameter. Many of the carriers left traces of powder on the chamber walls 4 meters from the burst point, indicating a potential of 250 to 300 cu m cloud volume. Further evaluation is needed to optimize the discharge rate as well as the size and number of carriers to determine the optimum relationship of grenade payload/cloud size/agent concentration.

In addition to techniques for extending the cloud, different casing and burster materials should be considered for use in an RC grenade such as the M25A2. A nonrigid case, perhaps of soft vinyl, would eliminate fragment hazard. The case should be molded to rupture into small pieces to

avoid powder dumping or partial unloading through casing tears. The use of high energy explosives are neither required or desired because of their blast hazard and possible compaction effects on the loose powder. A burster of low brisance and high gas volume, such as a gun powder or propellant, should also be evaluated.

V. CONCLUSIONS.

It was found that:

1. A two- to threefold increase in dissemination efficiency can be realized by control of initial powder size.

2. The M25A2 burster can be reduced by one-half without adversely affecting dissemination efficiency.

3. Use of agent carriers may offer a technique for increasing effective cloud volume.